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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] this invention relates to the fuel cell system equipped with the configuration which heats in detail the fuel gas and oxidant gas which were humidified about the fuel cell system which supplies the oxidant gas containing the fuel gas containing hydrogen, and oxygen to a fuel cell, and is made to generate by the chemical reaction of hydrogen and oxygen -- it comes out.
[0002]
[Description of the Prior Art] In recent years, various kinds of electric vehicles in which it replaces with the conventional engine and a drive motor is carried are developed. Development of the fuel cell powered vehicle which carries the hydrogen ion exchange membrane type fuel cell (henceforth a PEM mold fuel cell) called for short PEMFC (Proton Exchange Membrane Fuel Cell) as a power source of a drive motor as one of this kind of the electric vehicles is furthered quickly.
[0003] Said PEM mold fuel cell is constituted as a stack of the structure which carried out the laminating of many cels which are generation-of-electrical-energy units, and each cel has the structure which put the film and electrode zygote called MEA (Membrane ElectrodeAssembly) for short between the anode pole separator which has a hydrogen supply way, and the cathode pole separator which has an oxygen supply way. The laminating of an anode lateral electrode catalyst bed and the gaseous diffusion layer is carried out to one side of the hydrogen ion exchange film of the solid-state polymeric materials called PEM (Proton Exchange Membrane) for short one by one, the laminating of a cathode lateral electrode catalyst bed and the gaseous diffusion layer is carried out one by one, and this MEA is constituted by other one side of said PEM (hydrogen ion exchange film).
[0004] In this kind of PEM mold fuel cell, the hydrogen gas humidified as fuel gas carries out conduction of said hydrogen supply way toward an anode pole outlet side from an anode pole entrance side. If the air humidified as oxidant gas carries out conduction of said oxygen supply way toward a cathode pole outlet side from a cathode pole entrance side By a hydrogen ion's penetrating PEM (hydrogen ion exchange film) of MEA of a damp or wet condition from the anode pole side of each cel, and moving to a cathode pole side, the electromotive force each cel of whose is about 1V is generated. In this case, the output state most stabilized by the PEM mold fuel cell in the about 70-80-degree C temperature environment is acquired.
[0005] so, in the fuel cell system which used the PEM mold fuel cell which has such a generation-of-electrical-energy mechanism In order to supply continuously the air and hydrogen gas which were humidified, and to make a generation of electrical energy continue and to maintain a fuel cell to an optimum temperature range, For example, the air supply system which cools the air fed by the supercharger by the intercooler, and is supplied to a cathode pole entrance side, The air excretory system which discharges the surplus air of highly humid ** from a cathode pole outlet side, the hydrogen gas supply system which supplies the stored hydrogen gas to an anode pole entrance side, The hydrogen gas excretory system which discharges the surplus hydrogen gas of highly humid ** from an anode pole outlet side, The humidification equipment of the water transparency membrane type which humidifies

the air of said air supply system by moisture exchange between the surplus air of highly humid ** of said air excretory system, The cooling system which is made to circulate through the coolant between the humidification equipment of a water transparency membrane type, fuel cells, and heat exchangers which humidify the hydrogen gas of said hydrogen gas supply system by moisture exchange between the surplus hydrogen gas of highly humid ** of said hydrogen gas excretory system, and maintains a fuel cell to an optimum temperature range is established.

[0006] Here, generally the hollow fiber type humidifier (refer to JP,7-71795,A) lightweight and compact as said water transparency type of humidification equipment is used. Moreover, the ejector for water suction which sucks up the moisture which flows into a hydrogen gas excretory system to a hydrogen gas supply system as a means to humidify the hydrogen gas of said hydrogen gas supply system is also used. Generally the two-step cooling type which makes it circulate between a fuel cell and the primary heat exchanger of a liquid-liquid type by making the water solution of an ethylene glycol system without conductivity into the primary coolant, and circulates the secondary coolant as said cooling system on the other hand from a viewpoint which prevents the liquid junction phenomenon of a fuel cell between said primary heat exchangers and secondary heat exchangers (radiator) of a vapor-liquid type is adopted.

[0007] Said hollow fiber type humidifier consists of a hollow fiber module with which the hollow fiber aggregate of the structure which bundled several many hollow fibers of water permeability was held in cylindrical housing, and a head block connected with the both ends of this hollow fiber module, respectively. In this kind of hollow fiber type humidifier, the air which said air supply system dried, for example passes through the inside of said cylindrical housing from one head block as sweep gas, and carries out conduction to the head block of another side, and the surplus air of highly humid ** of said air excretory system passes through the interior of each hollow filament of said hollow fiber aggregate to coincidence from the head block of another side as cathode off-gas, and carries out conduction to it to one head block. And by performing moisture exchange between the air of highly humid ** of the air excretory system which passes through the interior of each hollow fiber, and the air which the air supply system which contacts the periphery of each hollow fiber and passes dried, the surplus air of highly humid ** of an air excretory system is dehumidified, and the air which the air supply system dried is humidified. Here, generally as said hollow fiber, the hollow fiber of the porosity which makes the moisture in gas penetrate according to a capillary condensation operation is used from a heat-resistant high thing. In addition, the nonvesicular hollow fibers (for example, Du Pont Nafion (trademark) etc.) which make only the moisture in gas penetrate by the ion hydration are also used.

[0008]

[Problem(s) to be Solved by the Invention] By the way, in the aforementioned fuel cell system, if the temperature of the air supplied to a cathode pole entrance side from an air supply system is low like [at the time of the starting] when the temperature of the fuel cell itself is low, the generation-of-electrical-energy engine performance of a fuel cell will fall. When an OAT is low especially, the temperature of the air supplied to a cathode pole entrance side becomes still lower, and since the dew-point of the air humidified in addition becomes low and the amount of humidification falls, there is a problem that the generation-of-electrical-energy engine performance of a fuel cell falls extremely. And another problem that the endurance of a fuel cell falls is also generated in this case. On the other hand, since the temperature of the hydrogen gas supplied to an anode pole entrance side falls with the latent heat of vaporization accompanying actuation of the ejector for water suction when the hydrogen gas of said hydrogen gas supply system is being humidified with the ejector for water suction, the time of starting of a fuel cell, and when outside air temperature is low, the same problem as the above occurs.

[0009] Then, this invention makes it a technical problem to offer the fuel cell system which can prevent the generation-of-electrical-energy performance degradation of a fuel cell when an OAT is low, the time of starting with the low temperature of the fuel cell itself, and, as a result can prevent the fall of the endurance of a fuel cell.

[0010]

[Means for Solving the Problem] As a means to solve the aforementioned technical problem, the fuel cell system concerning this invention The cooling system which cools a fuel cell by the coolant which

circulates through between a fuel cell and heat exchangers, The humidification equipment of the water transparency membrane type which humidifies the oxidant gas supplied to a cathode pole entrance side by the moisture exchange between the cathode off-gas of highly humid ** discharged from the cathode pole outlet side of a fuel cell, It is the fuel cell system by which the humidification equipment of the water transparency membrane type which humidifies the fuel gas supplied to an anode pole entrance side by the moisture exchange between the off-gas of highly humid ** discharged from the outlet side of the anode pole of a fuel cell or a cathode pole was attached. It is characterized by establishing a heating means to heat said oxidant gas and fuel gas by the coolant of said cooling system which carries out endoergic from said fuel cell, and goes to a heat exchanger.

[0011] In the fuel cell system concerning this invention, if oxidant gas is supplied to the cathode pole entrance side of a fuel cell by the starting and fuel gas is supplied to an anode pole entrance side, a fuel cell starts a generation of electrical energy, from a cathode pole outlet side, the cathode off-gas of excessive highly humid ** will be discharged, and the fuel gas of excessive highly humid ** will be discharged from an anode pole outlet side. And when the cathode off-gas of highly humid ** discharged from a cathode pole outlet side and the oxidant gas supplied to a cathode pole entrance side carry out moisture exchange with the humidification equipment of a water transparency membrane type, the cathode off-gas discharged is dehumidified and the oxidant gas supplied is humidified. When similarly the off-gas of highly humid ** discharged from the outlet side of an anode pole or a cathode pole and the fuel gas supplied to an anode pole entrance side carry out moisture exchange with the humidification equipment of a water transparency membrane type, the off-gas discharged is dehumidified and the fuel gas supplied is humidified. On the other hand, the coolant of a cooling system circulates through between a fuel cell and heat exchangers so that a fuel cell may be held to an optimum temperature range. The humidified fuel gas which is supplied to the oxidant gas and the anode pole entrance side by which a heating means is supplied to a cathode pole entrance side, and which were humidified is heated, respectively by making into a heat source the coolant which carries out endoergic from a fuel cell and goes to a heat exchanger in that case.

[0012] In the fuel cell system of this invention, when it is constituted so that oxidant gas and fuel gas may be heated, respectively, when said heating means heats the humidification equipment of said oxidant gas, and the humidification equipment of said fuel gas, since said humidification equipment can be humidified to the high oxidant gas and the fuel gas of dew point temperature, respectively and can increase oxidant gas and the amount of humidification of fuel gas, it is desirable.

[0013] Said heating means may be constituted so that oxidant gas and fuel gas may be heated through the heat exchanger prepared in the heat exchanger prepared in the supply path of said oxidant gas, and the supply path of said fuel gas, respectively. In this case, if each heat exchanger is arranged at the upstream of each humidification equipment, respectively, since the temperature of the oxidant gas supplied to humidification equipment, respectively and fuel gas can be raised beforehand, it can go up that dew point temperature and the oxidant gas by humidification equipment and the amount of humidification of fuel gas can be increased promptly, it is desirable.

[0014] Moreover, said heating means may be constituted so that oxidant gas may be heated through the intercooler prepared in the upstream from said humidification equipment of the supply path of said oxidant gas. In this case, the temperature of the oxidant gas supplied to humidification equipment can be raised beforehand, that dew point temperature can be gone up, and the amount of humidification of the oxidant gas by humidification equipment can be increased promptly. Moreover, since it is not necessary to prepare a special heat exchanger etc., a fuel cell system can be constituted in a compact. In addition, it is desirable to establish means for switching, such as a method change-over valve of three, so that the coolant which carries out endoergic from a fuel cell and goes to a heat exchanger, and the coolant which radiates heat by the heat exchanger and goes to a fuel cell may be switched to the circulation path of the coolant of said cooling system and said intercooler can be supplied.

[0015] Furthermore, by heating the ejector for water suction formed in the supply path of said fuel gas, said heating means may be constituted so that fuel gas may be heated. In this case, since the temperature fall of the fuel gas by the latent heat of vaporization at the time of the ejector for water suction

humidifying fuel gas can be prevented, the dew point temperature of fuel gas can be gone up and the amount of humidification of the fuel gas by the ejector for water suction can be increased, it is desirable.

[0016]
[Embodiment of the Invention] Hereafter, the gestalt of operation of the fuel cell system applied to this invention with reference to a drawing is explained. In the drawing to refer to, drawing 1 is the block diagram showing typically the fuel cell system concerning the 1st operation gestalt. The fuel cell system of the 1st operation gestalt shown in drawing 1 is a fuel cell system by which the air supply system 2, the air excretory system 3, the hydrogen gas supply system 4, the hydrogen gas excretory system 5, and the cooling system 6 were attached to the fuel cell (FC) 1, for example, is carried in a fuel cell electric vehicle as a drive power source of a drive motor.
[0017] The output state stabilized most is acquired in the temperature environment which said fuel cell (FC) 1 is a PEM mold fuel cell of the structure where the laminating of many cels which are generation-of-electrical-energy units was carried out, for example, is about 70-80 degrees C. The circuitry of this fuel cell (FC) 1 is carried out so that electric power may be supplied to the drive unit of a dc-battery and a drive motor through the output current control device which is not illustrated.
[0018] Said air supply system 2 supplies the air as oxidant gas containing oxygen to the cathode pole entrance side of a fuel cell (FC) 1. For this reason, supercharger (S/C) 2A and intercooler (I/C) 2B are arranged in the air supply system 2 toward the downstream from that upstream. Moreover, in order to heat and humidify the air supplied to a cathode pole entrance side, heat exchanger (H/E) 2C and hollow fiber type humidifier 2D as humidification equipment of a water transparency membrane type are arranged in the downstream of said intercooler (I/C) 2B. In addition, the silencer and air filter which are not illustrated are arranged in the upstream of said supercharger (S/C) 2A.
[0019] Said air excretory system 3 discharges the cathode off-gas of highly humid ** which is the surplus air which contained reaction water from the cathode pole outlet side of a fuel cell (FC) 1. In order to humidify the air supplied to said cathode pole entrance side by the cathode off-gas of this highly humid **, said hollow fiber type humidifier 2D is arranged in the air excretory system 3, and emission-control valve 3A of cathode off-gas is interposed in that downstream.
[0020] Said hydrogen gas supply system 4 circulates through and supplies the hydrogen gas as fuel gas to the anode pole entrance side of a fuel cell (FC) 1. For this reason, hydrogen tank 4A and ejector 4B are arranged by the hydrogen gas supply system 4. Moreover, in order to heat and humidify the hydrogen gas supplied to an anode pole entrance side, heat exchanger (H/E) 4C is arranged in the upstream of said ejector 4B, and hollow fiber type humidifier 4D as humidification equipment of a water transparency membrane type is arranged in the downstream of ejector 4B. Moreover, between the downstream of said heat exchanger (H/E) 4C, and the downstream of hollow fiber type humidifier 4D, ejector 4E for water suction (in explanation of the gestalt of implementation of invention, it is hereafter called for short "water suction ejector 4E".) is interposed in this hollow fiber type humidifier 4D and juxtaposition.
[0021] Said ejector 4B and water suction ejector 4E carry out pressure conversion of the mainstream rate of flow by the diffuser and nozzle which are not illustrated, are a kind of jet pump constituted so that a suction room might be made to generate negative pressure, and are [they are easy structure, and actuation and maintenance are easy for them, and] excellent in endurance. Said ejector 4B attracts the anode off-gas discharged by the hydrogen gas excretory system 5, and the hydrogen gas supply system 4 is made to circulate through it here. On the other hand, water suction ejector 4E attracts the water of condensation in the anode off-gas discharged by the hydrogen gas excretory system 5, and flows back to the hydrogen gas supply system 4.
[0022] Said hydrogen gas excretory system 5 discharges the anode off-gas of highly humid ** which is surplus hydrogen gas which contained reaction water from the anode pole outlet side of a fuel cell (FC) 1. In order to humidify the hydrogen gas supplied to said anode pole entrance side by the cathode off-gas of this highly humid **, said hollow fiber type humidifier 4D is arranged in the hydrogen gas excretory system 5, and emission-control valve 5A of anode off-gas is interposed in that downstream.

[0023] Said cooling system 6 cools a fuel cell (FC) 1 to an optimum temperature range by the coolant which circulates through between a fuel cell (FC) 1 and heat exchanger 6A. for this reason -- a cooling system -- six -- a heat exchanger -- six -- A -- having radiated heat -- the coolant -- a circulating pump -- six -- B -- a fuel cell -- (-- FC --) -- one -- sending out -- a cooling fluid flow -- an outward trip -- six -- C -- a fuel cell -- (-- FC --) -- one -- from -- endoergic -- having carried out -- the coolant -- a heat exchanger -- six -- A -- returning -- a cooling fluid flow -- a return trip -- six -- D -- at least -- having -- **** . In addition, although illustration was omitted, in order to promote warming up of a fuel cell (FC) 1, the thermostat bulb which opens and closes the bypass passage and this bypass passage of heat-exchanger 6A according to the laying temperature of the coolant is prepared in this cooling system 6. In addition, the laying temperature of the coolant which opens said bypass passage is usually set as about 70 degrees C, and the laying temperature of the coolant which closes bypass passage is usually set as about 80 degrees C.

[0024] When said cooling system 6 does not have like illustration of the secondary cooling system which has the circulating flow way of the secondary coolant, said heat-exchanger 6A consists of so-called air-cooled (vapor-liquid type) radiators in which heat exchange is possible between atmospheric air. In addition, when the cooling system 6 is equipped with the secondary cooling system which has a radiator, said heat exchanger 6A consists of heat exchangers of the liquid-liquid type in which heat exchange is possible between secondary coolant.

[0025] In order to prevent the liquid junction phenomenon of said fuel cell (FC) 1, as coolant which circulates through between said heat exchanger 6A and fuel cells (FC) 1, the water solution of the pure water with which conductivity was maintained low, or an ethylene glycol system without conductivity is usually used. Moreover, the piping material of cooling-fluid-flow outward trip 6C and cooling-fluid-flow return trip 6D consists of plastic conduits in which insulation is high and ion cannot be eluted easily.

[0026] Here, in the fuel cell system of the 1st operation gestalt, a means to heat the hydrogen gas supplied to the air and the anode pole entrance side which are supplied to the cathode pole entrance side of said fuel cell (FC) 1 by the coolant which carries out endoergic from the fuel cell (FC) 1 of said cooling system 6, and goes to heat exchanger 6A is established. That is, cooling-fluid-flow return trip 6D which goes to heat exchanger 6A from a fuel cell (FC) 1 is piped so that the coolant may circulate through hollow fiber type humidifier 2D, may circulate through return and heat exchanger (H/E) 2C to heat exchanger 6A and may return to heat exchanger 6A, in order to heat the air which carries out conduction of the air supply system 2. Cooling-fluid-flow return trip 6D which similarly goes to heat exchanger 6A from a fuel cell (FC) 1 is piped so that the coolant may circulate through hollow fiber type humidifier 4D, may circulate through return and heat exchanger (H/E) 4C to heat exchanger 6A, may return to heat exchanger 6A, may circulate through water suction ejector 4E further and may return to heat exchanger 6A, in order to heat the hydrogen gas which carries out conduction of the hydrogen gas supply system 4.

[0027] Hollow fiber type humidifier 2D of said air supply system 2 is equipped with the hollow fiber module which comes to hold the hollow fiber aggregate of the structure which bundled several porous many hollow fibers of water permeability in cylindrical housing with which two or more gas incurrent pores were arranged by the end section along the hoop direction, and two or more gas outflow holes were arranged by the other end along the hoop direction. The other end connects this hollow fiber module, and it is supported by the head block of another side where the end section connects with a head block, and it is supported, and while it has a sweep gas inflow path and an off-gas outflow path has a sweep gas outflow path and an off-gas inflow path. And the engine water jacket which is the circuit of the coolant is prepared in the perimeter of said cylindrical housing at this hollow fiber type humidifier 2D.

[0028] In said hollow fiber type humidifier 2D The dry air fed by supercharger (S/C) 2A of said air supply system 2 to the cathode pole entrance side of a fuel cell (FC) 1 as sweep gas Pass through the inside of said cylindrical housing from the sweep gas inflow path of one head block, and conduction is carried out to the sweep gas outflow path of the head block of another side. To coincidence The surplus

air of highly humid ** of the air excretory system 3 discharged from the cathode pole outlet side of a fuel cell (FC) 1 as cathode off-gas It passes through the interior of each hollow filament of said hollow fiber aggregate from the off-gas inflow path of the head block of another side, and conduction is carried out to the off-gas outflow path of one head block. And by performing moisture exchange between the cathode off-gas which is the surplus air of highly humid ** which passes through the interior of each hollow fiber, and the dry air which contacts the periphery of each hollow fiber as sweep gas, and is passed, the cathode off-gas of highly humid ** of the air excretory system 3 is dehumidified, and the air which the air supply system 2 dried is humidified.

[0029] In addition, since hollow fiber type humidifier 4D of the hydrogen gas supply system 4 has the same structure as said hollow fiber type humidifier 2D, the detailed explanation about the structure is omitted. In this hollow fiber type humidifier 4D, the surplus hydrogen gas of highly humid ** of the hydrogen gas excretory system 5 passes through the interior of each hollow fiber as anode off-gas, the hydrogen gas which the hydrogen gas supply system 4 dried contacts the periphery of each hollow fiber as sweep gas, and passes, the surplus hydrogen gas of highly humid ** of the hydrogen gas excretory system 5 is dehumidified, and the hydrogen gas which the hydrogen gas supply system 4 dried is humidified.

[0030] Said heat exchanger (H/E) 2C is the heat exchanger of the vapor-liquid type which carries out heat exchange between the air of the air supply system 2, and the coolant of a cooling system 6. Similarly, said heat exchanger (H/E) 4C is the heat exchanger of the vapor-liquid type which carries out heat exchange between the hydrogen gas of the hydrogen gas supply system 4, and the coolant of a cooling system 6. On the other hand, said water suction ejector 4E attracts the water of condensation in the anode off-gas which passes hollow fiber type humidifier 4D from the anode pole outlet side of said fuel cell (FC) 1, and is discharged by the hydrogen gas excretory system 5. And by passing the diffuser and nozzle which the hydrogen gas which the hydrogen gas supply system 4 dried does not illustrate, it mixes to the hydrogen gas which dried the attracted water of condensation, and this water suction ejector 4E humidifies hydrogen gas. The engine water jacket which is the circuit of the coolant is prepared in the perimeter of this water suction ejector 4E.

[0031] In the fuel cell system of the 1st operation gestalt constituted as mentioned above, the air fed by the starting from supercharger (S/C) 2A of the air supply system 2 is supplied to the cathode pole entrance side of a fuel cell (FC) 1 via intercooler (I/C) 2B, heat exchanger (H/E) 2C, and hollow fiber type humidifier 2D. The hydrogen gas from hydrogen tank 4A of the hydrogen gas supply system 4 is supplied to coincidence at the anode pole entrance side of a fuel cell (FC) 1 via heat exchanger (H/E) 4C and ejector 4B and hollow fiber type humidifier 4D. Thereby, a fuel cell (FC) 1 starts a generation of electrical energy, from the cathode pole outlet side, the air of excessive highly humid ** is discharged as cathode off-gas, and the hydrogen gas of excessive highly humid ** is discharged as anode off-gas from an anode pole outlet side.

[0032] in this way -- a fuel cell -- a system -- starting -- if -- a fuel cell -- (-- FC --) -- one -- a cathode -- a pole -- an outlet side -- from -- discharging -- having -- air -- an excretory system -- three -- highly humid -- ** -- a cathode -- off-gas -- a fuel cell -- (-- FC --) -- one -- a cathode -- a pole -- an entrance side -- supplying -- having -- air supply -- a system -- two -- air -- between -- a hollow fiber -- a formula -- a humidifier -- 2D -- moisture -- exchange -- carrying out -- having -- air -- an excretory system -- three -- a cathode -- off-gas -- dehumidifying -- having -- air supply -- a system -- two -- air -- humidifying -- having . the same -- a fuel cell -- (-- FC --) -- one -- an anode -- a pole -- an outlet side -- from -- discharging -- having -- hydrogen gas -- an excretory system -- five -- highly humid -- ** -- an anode -- off-gas -- a fuel cell -- (-- FC --) -- one -- an anode -- a pole -- an entrance side -- supplying -- having -- hydrogen -- a gas supply system -- four -- hydrogen gas -- between -- a hollow fiber -- a formula -- a humidifier -- four -- D -- moisture -- exchange -- carrying out -- having -- hydrogen gas -- an excretory system -- five -- an anode -- off-gas -- dehumidifying -- having -- hydrogen -- a gas supply system -- four -- hydrogen gas -- humidifying -- having . Moreover, when water suction ejector 4E attracts the moisture discharged by the hydrogen gas excretory system 5 and is mixed to the hydrogen gas of the hydrogen gas supply system 4, it humidifies.

[0033] On the other hand, the coolant circulates through between a fuel cell (FC) 1 and heat exchanger 6A through cooling-fluid-flow outward trip 6C and cooling-fluid-flow return trip 6D with actuation of circulating-pump 6B of a cooling system 6 so that a fuel cell (FC) 1 may be held to an optimum temperature range. In that case, the coolant which carried out endoergic from the fuel cell (FC) 1 circulates through hollow fiber type humidifier 2D, heat exchanger (H/E) 2C, hollow fiber type humidifier 4D, heat exchanger (H/E) 4C, and water suction ejector 4E by cooling-fluid-flow return trip 6D, and it returns to heat exchanger 6A, heating these. For this reason, the air which carries out conduction of the air supply system 2 is heated through said hollow fiber type humidifier 2D and heat exchanger (H/E) 2C. Similarly, the hydrogen gas which carries out conduction of the hydrogen gas supply system 4 is heated through said hollow fiber type humidifier 4D, heat exchanger (H/E) 4C, and water suction ejector 4E.

[0034] Therefore, according to the fuel cell system concerning the 1st operation gestalt, the time of starting with the low temperature of fuel cell (FC)1 the very thing, and when an OAT is low, the temperature of the hydrogen gas supplied to the air and the anode pole entrance side which are supplied to the cathode pole entrance side of a fuel cell (FC) 1 can be maintained to the temperature of a fuel cell (FC) 1 and an abbreviation EQC. Moreover, the fall of the dew point temperature of said air supplied and hydrogen gas is prevented, and the fall of the amount of humidification can be prevented. Consequently, the generation-of-electrical-energy performance degradation of a fuel cell (FC) 1 can be prevented, as a result the fall of the endurance of a fuel cell (FC) 1 can be prevented.

[0035] Here, in the fuel cell system of the 1st operation gestalt, since heat exchanger (H/E) 2C of the upstream heats beforehand the air supplied to hollow fiber type humidifier 2D of the air supply system 2 and the hollow fiber type humidifier 2D itself heats further, hollow fiber type humidifier 2D can be humidified to the high air of dew point temperature, and can increase the amount of humidification of air. Since similarly heat exchanger (H/E) 4C of the upstream heats beforehand the hydrogen gas supplied to hollow fiber type humidifier 4D of the hydrogen gas supply system 4, hollow fiber type humidifier 4D can be humidified to the high hydrogen gas of dew point temperature, and can increase the amount of humidification of hydrogen gas. Moreover, the temperature fall of the hydrogen gas by the latent heat of vaporization at the time of humidifying hydrogen gas is prevented by heating water suction ejector 4E. Consequently, the dew point temperature of the hydrogen gas in water suction ejector 4E can rise, and the amount of humidification of the hydrogen gas by water suction ejector 4E can be increased.

[0036] Next, the fuel cell system applied to the 2nd operation gestalt of this invention with reference to drawing 2 is explained. The fuel cell system concerning the 2nd operation gestalt changes hollow fiber type humidifier 4D arranged ranging over the hydrogen gas supply system 4 and the hydrogen gas excretory system 5 in the fuel cell system of the 1st operation gestalt into hollow fiber type humidifier 4G arranged ranging over the hydrogen gas supply system 4 and the air excretory system 3. Since the component of others of the fuel cell system concerning the 2nd operation gestalt is the same as that of the fuel cell system of the 1st operation gestalt, the same sign is attached and detailed explanation is omitted.

[0037] In the fuel cell system of the 2nd operation gestalt said hollow fiber type humidifier 4G It passes through the interior of each hollow filament of said hollow fiber aggregate, surplus air of highly humid ** of the air excretory system 3 discharged from the cathode pole outlet side of a fuel cell (FC) 1 being used as off-gas. Moreover, the dry hydrogen gas sent out from ejector 4B of the hydrogen gas supply system 4 being used as sweep gas, it is constituted so that the periphery of each hollow fiber may be contacted and it may pass. Moreover, each of this hollow fiber of hollow fiber type humidifier 4G makes only moisture penetrate by the ion hydration, and oxygen etc. is constituted by the nonvesicular hollow fiber which is not made to penetrate. And in order to heat the hydrogen gas of the hydrogen gas supply system 4 which passes these hollow fiber type humidifier 4G, cooling-fluid-flow return trip 6D of said cooling system 6 is piped so that it may circulate through hollow fiber type humidifier 4G and may return to heat exchanger 6A.

[0038] the -- two -- operation -- a gestalt -- a fuel cell -- a system -- setting -- a fuel cell -- (-- FC --) --

one -- a cathode -- a pole -- an outlet side -- from -- discharging -- having -- air -- an excretory system -- three -- highly humid -- ** -- a cathode -- off-gas -- a fuel cell -- (-- FC --) -- one -- an anode -- a pole -- an entrance side -- supplying -- having -- hydrogen -- a gas supply system -- four -- hydrogen gas -- between -- a hollow fiber -- a formula -- a humidifier -- four -- G -- moisture -- exchange -- carrying out -- having . In that case, in hollow fiber type humidifier 4G, transparency of the oxygen contained in cathode off-gas is prevented, only the moisture contained in cathode off-gas penetrates each nonvesicular hollow fiber by the ion hydration, and the hydrogen gas which the hydrogen gas supply system 4 dried with this moisture to penetrate is humidified. And when the coolant of the cooling system 6 which carried out endoergic [of these hollow fiber type humidifier 4G] from the fuel cell (FC) 1 circulates by cooling-fluid-flow return trip 6D, the hydrogen gas which carries out conduction of the hydrogen gas supply system 4 is heated through hollow fiber type humidifier 4G.

[0039] In addition, in order to do the same operation effectiveness so in the fuel cell system of the 2nd operation gestalt about the same component as the fuel cell system of the 1st operation gestalt, According to the fuel cell system of the 2nd operation gestalt, the time of starting with the low temperature of fuel cell (FC)1 the very thing, and when an OAT is low, it also sets. The temperature of the hydrogen gas supplied to the air and the anode pole entrance side which are supplied to the cathode pole entrance side of a fuel cell (FC) 1 is maintainable to the temperature of a fuel cell (FC) 1 and an abbreviation EQC. Moreover, the fall of the dew point temperature of said air supplied and hydrogen gas is prevented, and the fall of the amount of humidification can be prevented. Consequently, the generation-of-electrical-energy performance degradation of a fuel cell (FC) 1 can be prevented, as a result the fall of the endurance of a fuel cell (FC) 1 can be prevented.

[0040] Then, the fuel cell system applied to the 3rd operation gestalt of this invention with reference to drawing 3 is explained. The fuel cell system concerning the 3rd operation gestalt eliminates heat exchanger (H/E) 2C from the air supply system 2 in the fuel cell system of the 1st operation gestalt, and changes the piping configuration of cooling-fluid-flow outward trip 6C of a cooling system 6, and cooling-fluid-flow return trip 6D. Since the component of others of the fuel cell system concerning the 3rd operation gestalt is the same as that of the fuel cell system of the 1st operation gestalt, the same sign is attached and detailed explanation is omitted.

[0041] In the fuel cell system of the 3rd operation gestalt, without the coolant circulating through hollow fiber type humidifier 2D, cooling-fluid-flow return trip 6D of a cooling system 6 is piped so that it may circulate through intercooler (I/C) 2B and may return to heat exchanger 6A. In this cooling-fluid-flow return trip 6D, method valve of three 6F are interposed in the part which method valve of three 6E is interposed in the part which goes to intercooler (I/C) 2B from a fuel cell (F/C) 1, and returns from intercooler (I/C) 2B to heat exchanger 6A. And branching passage 6G which branch from cooling-fluid-flow outward trip 6C, and are connected to method valve of three 6E, and unification passage 6H which branch from method valve of three 6F, and join cooling-fluid-flow outward trip 6C are prepared in the downstream of circulating-pump 6B so that circulation of the coolant sent out to said intercooler (I/C) 2B from circulating-pump 6B may be enabled.

[0042] In the fuel cell system of the 3rd operation gestalt The time of starting with the low temperature of fuel cell (F/C) 1 the very thing, and when an OAT is low, Method valve of three 6E opens for free passage cooling-fluid-flow return trip 6D which intercepts branching passage 6G and goes to intercooler (I/C) 2B from a fuel cell (F/C) 1. Method valve of three 6F switch a duct so that cooling-fluid-flow return trip 6D which intercepts unification passage 6H and returns from intercooler (I/C) 2B to heat exchanger 6A may be opened for free passage. Consequently, the coolant of cooling-fluid-flow return trip 6D circulates through intercooler (I/C) 2B. For this reason, the air of the air supply system 2 supplied to hollow fiber type humidifier 2D by supercharger (S/C) 2A is heated by the coolant of cooling-fluid-flow return trip 6D which carried out endoergic from the fuel cell (FC) 1 by that intermediate intercooler (I/C) 2B. Therefore, hollow fiber type humidifier 2D can be humidified to the high air of dew point temperature, and can increase the amount of humidification of air.

[0043] In addition, if warming up of a fuel cell (F/C) 1 is completed, said method valve of three 6E will open branching passage 6G for free passage to cooling-fluid-flow return trip 6D which goes to

intercooler (I/C) 2B, and method valve of three 6F will switch a duct so that cooling-fluid-flow return trip 6D from intercooler (I/C) 2B may be opened for free passage to unification passage 6H. Consequently, it circulates through the coolant sent out from circulating-pump 6B to intercooler (I/C) 2B.

[0044] In order that the same component as the fuel cell system of the 1st operation gestalt may do the same operation effectiveness so according to the fuel cell system of the 3rd operation gestalt, The time of starting with the low temperature of fuel cell (FC)1 the very thing, and when an OAT is low, the temperature of the hydrogen gas supplied to the air and the anode pole entrance side which are supplied to the cathode pole entrance side of a fuel cell (FC) 1 can be maintained to the temperature of a fuel cell (FC) 1 and an abbreviation EQC. Moreover, the fall of the dew point temperature of said air supplied and hydrogen gas is prevented, and the fall of the amount of humidification can be prevented. Consequently, the generation-of-electrical-energy performance degradation of a fuel cell (FC) 1 can be prevented, as a result the fall of the endurance of a fuel cell (FC) 1 can be prevented.

[0045] Next, the fuel cell system applied to the 4th operation gestalt of this invention with reference to drawing 4 is explained. The fuel cell system concerning the 4th operation gestalt eliminates heat exchanger (H/E) 2C from the air supply system 2 in the fuel cell system of the 1st operation gestalt, and heat exchanger (H/E) 4C and water suction ejector 4E is eliminated from the hydrogen gas supply system 4, and the piping configuration of cooling-fluid-flow return trip 6D of a cooling system 6 is changed according to this. In the fuel cell system of this 4th operation gestalt, heater 2E, such as an electric heater, is interposed in the downstream of hollow fiber type humidifier 2D of the air supply system 2, and the heater 4F [same] also as the downstream of hollow fiber type humidifier 4D of the hydrogen gas supply system 4 are interposed. In addition, since the component of others of the fuel cell system concerning the 4th operation gestalt is the same as that of the fuel cell system of the 1st operation gestalt, the same sign is attached and detailed explanation is omitted.

[0046] In the fuel cell system of the 4th operation gestalt, the time of starting with the low temperature of fuel cell (FC)1 the very thing, and when an OAT is low, the air supplied to the cathode pole entrance side of a fuel cell (FC) 1 by supercharger (S/C) 2A of the air supply system 2 is heated by heater 2E immediately after humidifying by hollow fiber type humidifier 2D. Moreover, the hydrogen gas supplied to the anode pole entrance side of a fuel cell (FC) 1 from hydrogen tank 4A is heated by heater 4F immediately after humidifying by hollow fiber type humidifier 4D. Consequently, the temperature of the air supplied to a fuel cell (FC) 1 and hydrogen gas can be raised, the moisture solidified by the rise of the dew point temperature can also be made to be able to evaporate, and air and the amount of humidification of hydrogen gas can be increased.

[0047] In addition, in order to do the same operation effectiveness so in the fuel cell system of the 4th operation gestalt about the same component as the fuel cell system of the 1st operation gestalt, According to the fuel cell system of the 4th operation gestalt, the time of starting with the low temperature of fuel cell (FC)1 the very thing, and when an OAT is low, it also sets. The temperature of the hydrogen gas supplied to the air and the anode pole entrance side which are supplied to the cathode pole entrance side of a fuel cell (FC) 1 is maintainable to the temperature of a fuel cell (FC) 1 and an abbreviation EQC. Moreover, the fall of the dew point temperature of said air supplied and hydrogen gas is prevented, and the fall of the amount of humidification can be prevented. Consequently, the generation-of-electrical-energy performance degradation of a fuel cell (FC) 1 can be prevented, as a result the fall of the endurance of a fuel cell (FC) 1 can be prevented.

[0048] In addition, hollow fiber type humidifier 2D and hollow fiber type humidifier 4D in the fuel cell system of each 1st, 3rd, or 4th operation gestalt may constitute the hollow fiber aggregate of a hollow fiber module from a nonvesicular hollow fiber with an ion hydration like hollow fiber type humidifier 4G in the fuel cell system of the 2nd operation gestalt. This nonvesicular hollow fiber makes only the moisture in gas penetrate by the ion hydration, prevents transparency of other gas constituents, and is known as Du Pont Nafion (trademark) etc.

[0049]

[Effect of the Invention] As explained above, if oxidant gas is supplied to the cathode pole entrance side

of a fuel cell by the starting and fuel gas is supplied to an anode pole entrance side, in the fuel cell system concerning this invention, a fuel cell starts a generation of electrical energy, from a cathode pole outlet side, the air of excessive highly humid ** will be discharged as cathode off-gas, and the fuel gas of excessive highly humid ** will be discharged as anode off-gas from an anode pole outlet side. And when the cathode off-gas of highly humid ** discharged from a cathode pole outlet side and the oxidant gas supplied to a cathode pole entrance side carry out moisture exchange with the humidification equipment of a water transparency membrane type, the cathode off-gas discharged is dehumidified and the oxidant gas supplied is humidified. When similarly the off-gas of highly humid ** discharged from the outlet side of an anode pole or a cathode pole and the fuel gas supplied to an anode pole entrance side carry out moisture exchange with the humidification equipment of a water transparency membrane type, the off-gas discharged is dehumidified and the fuel gas supplied is humidified. On the other hand, the coolant of a cooling system circulates through between a fuel cell and heat exchangers so that a fuel cell may be held to an optimum temperature range. The humidified fuel gas which is supplied to the oxidant gas and the anode pole entrance side by which a heating means is supplied to a cathode pole entrance side, and which were humidified is heated, respectively by making into a heat source the coolant which carries out endoergic from a fuel cell and goes to a heat exchanger in that case. Therefore, according to the fuel cell system concerning this invention, the temperature of the oxidant gas supplied when an OAT is low, the time of starting with the low temperature of the fuel cell itself and, and fuel gas is maintainable to the temperature of a fuel cell and an abbreviation EQC. Moreover, the fall of the dew point temperature of the oxidant gas supplied and fuel gas is prevented, and the fall of the amount of humidification can be prevented. Consequently, the generation-of-electrical-energy performance degradation of a fuel cell can be prevented, as a result the fall of the endurance of a fuel cell can be prevented.

[0050] In the fuel cell system of this invention, when it is constituted so that oxidant gas and fuel gas may be heated, respectively, when said heating means heats the humidification equipment of said oxidant gas, and the humidification equipment of said fuel gas, said humidification equipment can be humidified to the high oxidant gas and the fuel gas of dew point temperature, respectively, and can increase oxidant gas and the amount of humidification of fuel gas.

[0051] Moreover, when it is constituted so that oxidant gas and fuel gas may be heated through the heat exchanger prepared in the heat exchanger by which said heating means was formed in the supply path of said oxidant gas, and the supply path of said fuel gas, respectively, If each heat exchanger is arranged at the upstream of each humidification equipment, respectively, the temperature of the oxidant gas supplied to humidification equipment, respectively and fuel gas can be raised beforehand, the dew point temperature can be gone up, and the oxidant gas by humidification equipment and the amount of humidification of fuel gas can be increased promptly.

[0052] Furthermore, since it is not necessary to prepare a special heat exchanger etc. while being able to raise beforehand the temperature of the oxidant gas supplied to humidification equipment, being able to go up the dew point temperature and being able to increase promptly the amount of humidification of the oxidant gas by humidification equipment, when it is constituted so that said heating means may heat oxidant gas through the intercooler prepared in the upstream from said humidification equipment of the supply path of said oxidant gas, a fuel cell system can be constituted in a compact.

[0053] Moreover, when it is constituted so that fuel gas may be heated by heating the ejector for water suction with which said heating means was formed in the supply path of said fuel gas, the temperature fall of the fuel gas by the latent heat of vaporization at the time of the ejector for water suction humidifying fuel gas can be prevented, the dew point temperature of fuel gas can be gone up, and the amount of humidification of the fuel gas by the ejector for water suction can be increased.

[Translation done.]